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(54) Ink jet recording method

Farbstrahlaufzeichnungsverfahren

Méthode d'enregistrement par jet d'encre

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Description

The present invention relates to an ink-jet recording method for generating clear images by using a recording apparatus including an ink-jet recording head having a plurality of orifices.

In an ink-jet recording method for recording images on a recording medium such as a recording sheet by moving (main-scanning) an ink-jet recording head with a plurality of orifices relative to the recording medium, a so-called multi-droplet method has been conventionally used for representing a tone wedge or gradation of a recording image. In the multi-droplet method, a plurality of ink droplets are deposited at substantially the same position on a recording medium, and a pixel having an area according to the number of the plurality of ink droplets is formed. In this case, the tone wedge of the recording image is represented by forming a pixel having an area according to the image data.

When the multi-droplet method is used for recording images, all the images are generally recorded in such a way that the recording head is moved (main-scanning) relative to a recording medium for recording a part of the images, and then the recording head is moved (sub-scanning) perpendicularly to the direction of main-scanning and the main-scanning is carried out for recording another part of the images That is, the main-scanning and the sub-scanning are carried out by turns so that all the images are recorded on the recording medium. In the conventional ink-jet recording method, the above feed distance of the recording head in the sub-scanning direction is a distance which is a distance between two orifices provided on the recording head or a distance determined by the product of an orifice pitch and the number of orifices.

In the conventional ink-jet recording method, since, however, the feed distance in the sub-scanning direction is determined as the above described distance value, a portion not recorded of a so-called "white stripe banding" is generated in a recording image when an actual feed distance is greater than the predetermined distance value. On the other hand, when the actual feed distance is smaller than the predetermined value, there is a problem that ink droplets, the number of which is about twice as large as the number of ink droplets forming a predetermined pixel, land on the same position and a portion of a so-called "black stripe banding" of an extremely high image density is generated. In order to solve these problems, the feed distance in the sub-scanning direction may be precisely controlled so as to be always constant under any condition. However, this causes a very expensive manufacturing cost of the ink-jet recording apparatus.

Moreover, in the ink-jet recording head, volume of one ink droplet, which is discharged from one orifice in a vicinity of an edge portion of orifices disposed in a row, may fluctuate due to a temperature distribution in the use of the ink-jet recording head or unevenness of products caused by manufacturing a machining processes. As a result, in an image area, recorded in one main-scanning, unevenness of the image density may occur between portions recorded by the orifices in the vicinity of the edge portions of the recording head and portions recorded by other orifices.

As described above, in the conventional ink-jet recording method, the image quality in a vicinity of a boundary between an image area recorded in main-scanning and an image area recorded in next main-scanning may deteriorate for the above reasons.

European Patent Specification No. EP-0,376,596 discloses a printer in which a single pixel is normally formed by two ink droplets discharged from different nozzles and is accordingly not concerned with the above discussed problems.

In accordance with a first aspect of the present invention there is provided a method of ink jet recording as set out in claim 1.

In accordance with a second aspect of the present invention there is provided ink jet recording apparatus as set out in claim 7.

An embodiment of the present invention markedly reduces unevenness of an image density, resulting from a "black stripe" or a "white stripe" generated in a vicinity of a boundary between an image area formed in main-scanning and an image area formed in next main-scanning by simple control.

An embodiment of the present invention improves image quality of image areas including the boundary.

The above and other effects, features and advantages of the present invention will become more apparent from the following description of embodiments thereof taken in conjunction with the accompanying drawings and given by way of example.

Fig. 1 is a schematic perspective view of an ink-jet recording apparatus of embodiment 1 according to the present invention;

Fig. 2 is a block diagram of a control circuit of the ink-jet recording apparatus shown in Fig. 1;

Fig. 3 is a diagram explaining positions of a recording head relative to a recording medium of embodiment 1 according to the present invention shown in Fig. 1;

Fig. 4 is a diagram showing the number of ink droplets discharged from each orifice of the recording head of embodiment 1 according to the present invention;

Fig. 5 is a diagram showing a recorded result of embodiment 1 of the present invention;

Fig. 6 is a view showing a schematic perspective view of an ink-jet recording apparatus of embodiment 2 according to the present invention;

Fig. 7 is a diagram showing the number of ink droplets discharged from each orifice of the recording head of embodiment 2 according to the present invention;

Fig. 8 is a diagram showing the number of ink droplets discharged from each orifice of the r cording

head of embodiment 3 according to the present invention;

Fig. 9 is a diagram showing the relationship between the number of ink droplets and the image density for each pixel in embodiment 1 of the present invention;

Fig. 10 is a diagram explaining positions of the recording head relative to a recording medium of embodiment 4 according to the present invention;

Fig. 11 is a diagram showing a recorded result of embodiment 4 of the present invention;

Fig. 12 is a diagram showing the relationship between the number of ink droplets and the image density for each pixel in embodiment 4 of the present invention;

Fig. 13 is a diagram explaining positions of the recording head relative to a recording medium of embodiment 5 according to the present invention;

Fig. 14 is a diagram showing the relationship between the number of ink droplets and the image density for each pixel in embodiment 5 of the present invention;

Fig. 15 is a diagram showing a recorded result of embodiment 5 of the present invention;

Fig. 16 is a view showing a schematic perspective view of an ink-jet recording apparatus of embodiment 6 according to the present invention;

Fig. 17 is a diagram showing the relationship between the number of ink droplets and the image density for each pixel in embodiment 6 according to the present invention; and

Fig. 18 is a diagram showing a recorded result of embodiment 6 of the present invention.

Referring to the accompanying drawings, embodiments of the present invention will be described below.

(Embodiment 1)

Fig. 1 is a schematic perspective view of an ink-jet recording apparatus of embodiment 1 according to the present invention. In Fig. 1, reference numeral 1 denotes a recording head on which 128 ink orifices are disposed at a density of 16 orifices/mm. Each of orifices is provided with an electrothermal transducer for generating energy used for discharging ink in an ink path communicating to the orifice. Incidentally, in embodiments described here and hereinafter of the present invention, term "discharging portion", "outlet" or "nozzle" may be used instead of term "orifice". The electrothermal transducer generates heat in response to electric pulses applied thereto and then generates film boiling in ink with this heat, so that ink is discharged from the orifice according to the film boiling. In embodiment 1, the discharging frequency or the driving frequency for driving the electrothermal transducer is 2kHz.

Reference numeral 174 denotes a carriage for mounting and shifting the recording head 1. The carriage 174 is guided and shifted along two guide shafts 175A and 175B being slidably engaged with the carriage 174. Reference numeral 176 denotes an ink supplying tube which supplies ink from an ink tank (not shown) to the recording head 1. Reference numeral 177 denotes a flexible cable for transmitting driving signals and control signals based on recording data from a control unit of the recording apparatus (not shown) to the recording head driver being provided in a portion of the recording head 1. The ink supplying tube 176 and the flexible cable 177 are made of flexible members so that they can follow the movement of the carriage 174. The carriage 174 is connected to part of a belt (not shown) being stretched in parallel to the guide shafts 175A and 175B for shifting the carriage 174, and can be shifted by the belt driven by a carriage motor (not shown).

Reference numeral 173 denotes a platen whose longitudinal direction is parallel to the guide shafts 175A and 175B. Reference numeral 172 denotes a recording sheet as a recording medium.

The recording head 1 discharges ink in process of the movement of the carriage 174, so that an image area is recorded on a portion of the recording sheet 172 opposite to the orifices.

Fig. 2 is a block diagram showing a control circuit of the recording apparatus shown in Fig. 1. Reference numeral 201 denotes a main controller which controls the whole recording apparatus including the discharging timing, and is usually composed of a one-chip microprocessor or the like with a central processing unit (CPU), a read-only memory which stored a program (program ROM) and a random access memory used for work (work RAM) or the like. The main controller accepts image data signals for indicating the image density of each pixel from a host computer 203, and then stores the signals in units of frames onto a frame memory 205 as a buffer. When images are recorded, that is, when ink is discharged, the main controller 201 controls the drive of a carriage feed motor 209 via a first motor driver 207, and also controls a recording sheet feed motor 213 via a second motor driver 211. The main controller 201 reads image data from the frame memory 205, converts the image data into tone wedge data suitable for the recording apparatus, controls the ink discharging by the recording head 1 (explained hereinafter in more detail) via the driver controller 215 and a head driver 217, and then performs recording of tone wedge image on a recording sheet 172 whereby.

Embodiment 1 for performing 17-tone-wedge image recording by using the above described recording apparatus will be described below.

Fig. 3 is a diagram explaining the positional relationship of the recording head 1 relative to the recording sheet 172 each time the recording head 1 is main-scans. In Fig. 3, reference numeral 1 denotes a schematic diagram of the recording head 1 on which orifices are disposed in the vertical direction. For the sake of explanation, the orifices are numbered 1, 2, ..., 128 in the top-to-bottom direction. In Fig. 3, positions of the

recording head 1 are assumed to be shifted in the main-scanning direction. But, actually, each left side portion of the recording head 1 at each starting point of main-scanning is placed in the same vertical position. For the sake of explanation, it is assumed that the density of all the images t b recorded on a recording sheet is uniform, that is, each pixel on the sheet is assumed to be generated from the same number (N) of ink droplets.

When recording is performed on the recording sheet at the first main-scanning time, the orifices Nos. 1, 2, ..., and 128 are used. At this time, as shown in Fig. 4, the numbers of ink droplets discharged from the orifices Nos. 126, 127 and 128 are determined as N x 6/8, N x 4/8 and N x 2/8 respectively for forming the first image area.

Next, as shown in Fig. 3, a recording sheet is moved or sub-scanned upward by 125 pixels so that the orifices Nos. 1, 2, and 3 overlap part of the first image area formed by the orifices Nos. 126, 127 and 128 respectively, in the second main-scanning (in Fig. 3, the recording head 1 is moved downward relative to a recording sheet for convenience), and the orifice No. 1 is placed to the position of the orifice No. 126 in the first main-scanning.

After the completion of the above sub-scanning, the second image area is recorded at the second main-scanning in such a way that the numbers of ink droplets discharged from the orifices Nos. 1, 2 and 3 are N x 2/8, N x 4/8 and N x 6/8 respectively and the numbers of ink droplets discharged from the orifices Nos. 126, 127 and 128 are N x 6/8, N x 4/8 and N x 2/8, respectively as shown in Fig. 4. The overlapped portion of the first and second image areas is shown in Fig. 5.

Similarly, the recording of image area is repeated to form all the image areas of the images on the sheet. At the lowest image area of the images on the sheet, image recording is performed in such a way that the numbers of ink droplets discharged from the orifices Nos. 126, 127 and 128 are the same as the number of ink droplets discharged from the orifices Nos. 4 to 125.

Moreover, in the above explanation of the image recording, it has been assumed that pixels of recording image are made of the same number of ink droplets. Actually, the number of ink droplets forming each pixel according to image data differs from each other, and the number (N') of ink droplets (image density data) forming each pixel to be overlapped is multiplied by 2/8, 4/8, 6/8 or the like.

Moreover, if a volume of an ink droplet discharged from each orifice in a central portion of the recording head extremely differs from that in edge portions thereof, the values 2/8, 4/8, 6/8 and the like can be adjusted for each recording head according to the volume of an ink droplet.

(Embodiment 2)

Fig. 6 is a view showing construction of embodiment 2 of the recording apparatus according t the present invention. Reference numeral 41 denotes an ink-jet recording head having 512 orifices (at a density of 16 orifices/mm). The orifices are disposed in the lateral direction of Fig. 6. The recording head 41 is movable along a rail 44. Reference numerals 42 and 43 denote a recording sheet and a drum driven by a motor (not shown) respectively.

The 17-tone-wedge recording can be performed by the recording apparatus of embodiment 2. The number of orifices to perform overlapping image recording is two for each edge portion of the recording head.

First, the recording head 41 is positioned to the leftmost position in Fig. 6, and as shown in Fig. 7, image density data of the orifices Nos. 511 and 512 are made to be N x 6/8 and N x 2/8 respectively, and the drum 43 is made to make one revolution to perform the first image recording.

Next, the recording head 41 is shifted to the right by 511 pixel pitches, image density data of the orifices Nos. 1, 2, 511 and 512 are made to be N x 2/8, N x 6/8, N x 6/8 and N x 2/8 respectively to perform the second image recording. After the recording head is shifted to the right by 511 pixel pitches as shown above, the drum 43 is made to make one revolution. The above processing is repeated to perform recording of all the image areas. In the rightmost image area of the images on the sheet, like embodiment 1, the above processing is not performed on image density data of the orifices Nos. 511 and 512.

In embodiment 1, there are three orifices to perform overlapping recording for each edge portion of the recording head, and in embodiment 2, there are two orifices to perform the overlapping recording for each edge portion of the recording head. However, the number of orifices performing the overlapping recording is optionally selectable less than the number of all the orifices.

(Embodiment 3)

In embodiments 1 and 2, values by which image density data are multiplied, are standardized with respect to $1/2^n$ in order to be easily treated by hardware. However, it is not necessary to standardize the values based on $1/2^n$. For example, as shown in embodiment 3 in Fig. 8, if there are three overlapping orifices, the values can be 1/10, 1/2 and 9/10. In any case, the total of landed ink droplets may correspond to original image density data.

In the above embodiments, when one pixel is recorded in the overlapping image area, ink droplets are landed on substantially the same area twice at predetermined interval. A plurality of ink droplets to land at a first time or at a second time are defined by a first or second ink droplet group. For example, in Fig. 5, the amount of the first or second ink droplet group landed at the first time or the second time in a central pixel in the overlapping portion of image areas, is about a half of the amount of the ink droplets to be landed on a pixel on non-overlapping portion, so that th spread of the first

ink droplet group on a recording medium is smaller than that of ink droplets landed on the pixel on the non-overlapping portion. Moreover, a predetermined time is passed after the first main scanning, and then a previously landed the first ink droplet group is fixed in some degrees. In this state, when a next ink droplet group, the second ink droplet group, is landed on the same pixel on the recording sheet, the final size of the pixel is smaller than the size when the all the ink droplets are landed on the pixel at a time. When the number of pixels in the main-scanning direction is extremely large, the previously landed ink droplet group has been mostly fixed and the final size of the pixel becomes smaller than the size corresponding to the original image density data. The reason is that it takes a long time to record image data in the main-scanning direction.

For instance, if it takes a relatively long time to perform one main-scanning due to the large number of pixels to be recorded in the main-scanning direction, the size of pixel in an overlapping portion of image areas shown in Fig. 5 is smaller than the size of another pixel, and the image density of the overlapping portion becomes low. The image density distribution in this case is shown in Fig. 9.

In the embodiment described below, when a dot formed by landing a first ink droplet group on a recording medium portionally overlaps with a dot formed by landing a second ink droplet group on the recording medium, the size of one pixel formed by the dots is made larger by shifting a position of the landed first ink droplet from a position of the landed second ink droplet. This can reduce unevenness of the image density in the overlapping portion of the image areas.

(Embodiment 4)

In embodiment 4, 17-tone-wedge recording is performed by using the ink-jet recording apparatus shown in Fig. 1. Fig. 10 is a schematic diagram for explaining a recording method of embodiment 4, and like reference numerals designate like parts in Figs. 3 and 10.

Image area recording will be described below in which the number of orifices for recording an overlapping portion of the two image areas is three for each edge portion of the recording head and the highest image density of the overlapping area is formed by 16 ink droplets.

When recording is performed on a recording sheet, the orifices Nos. 1 to 128 are used and the orifices 126, 127 and 128 discharge 12, 8 and 4 ink droplets respectively.

Next, the recording sheet is moved or subscanned upward by 125 plus 1/3 pixel pitches (for convenience, the recording head 1 is moved downward relative to the recording sheet in Fig. 10).

Moreover, the numbers of ink droplets discharged from the orifices Nos. 1, 2 and 3 are 4, 8 and 12, and the numbers of ink droplets discharged from the orifices Nos. 126, 127 and 128 are 12, 8 and 4 respectiv ly.

Next, the recording sheet is moved upward by 125 minus 1/3 pixel pitches and the same numbers of ink droplets as described above are discharged on the recording sheet to perform recording.

The abov described operations are alternately repeated and finally all the image areas are formed.

As shown in Fig. 11, the area of pixels forming the overlapping portion between a first image area and a second image area can be widened by the above described recording method. Consequently, as shown in Fig. 12, the area of pixel forming the overlapping portion can be made approximately equal to an area of pixel forming another portion edge of the image area, and unevenness of the image density generated in the overlapping area can be markedly reduced.

(Embodiment 5)

In embodiment 5, five-tone-wedge recording is performed by using the ink-jet recording apparatus in Fig. 6. However, in embodiment 5, 128 orifices (16 orifices/mm) are disposed in the lateral direction of the recording head.

The number of orifices which record an overlapping portion is two for each edge portion of the recording head, and the highest image density of a pixel in the overlapping portion is formed by four ink droplets.

First, the recording head 41 is positioned to the leftmost position in Fig. 6. While the numbers of ink droplets discharged from the orifices Nos. 127 and 128 are 3 and 1 respectively, recording is performed during rotating the drum 43. At this time, a recording start position in the direction of the drum revolution is defined as H.

Next, the recording head 41 is shifted to the right by 126 pixel pitches as shown in Fig. 13. After this subscanning, as shown in Fig. 14, the numbers of ink droplets discharged from the orifices Nos. 1 and 2 are one and three, and the numbers of ink droplets discharged from the orifices Nos. 127 and 128 are three and one respectively so as to record a second image area. At this time, as shown in Fig. 13, the recording start position in the direction of the drum revolution is shifted from the record starting position H by 0.5 pixel pitch so as to start recording.

After the second image area has been formed, the recording head 41 is shifted to the right by 126 pixel pitches as shown in Fig. 13, and then, recording is performed at the recording start position H with the same numbers of ink droplets as described above.

The above described operations are repeated to perform recording of all the image areas. Fig. 15 illustrates the recording result of pixels recorded by the recording apparatus of embodiment 5.

(Embodiment 6)

Fig. 16 is the construction of an ink-jet recording apparatus of embodiment 6 according to the present

invention. Reference numeral 141 denotes an ink-jet recording head having 512 orifices (16 orifices/mm), and being disposed obliquely to the direction of revolution of the drum 41. The other construction is similar to the recording apparatus shown in Fig. 6.

The recording head 141 is first located on the right side of the drum 42, and is shifted from the right side to the left side by 510 plus 1/2 pixel pitches during one revolution of the drum 43. That is, sub-scanning of the recording head 141 has been completed when main-scanning in which the drum 43 makes one revolution is completed.

In embodiment 6, orifices are numbered 1, 2, ..., and 512 from the right side in Fig. 16, the number of orifices which perform overlapping portion are two for each edge portion of the recording head, and a pixel in the overlapping portion is generated by eight ink droplets.

First, when the first image area is formed or until the drum 43 makes a first revolution, eight ink droplets are discharged from orifices Nos. 1 to 510 and four ink droplets are discharged from orifices Nos. 511 and 512 so as to perform recording.

Thus, the first image area is formed, and the drum 43 makes one revolution so as to finish recording of the first image area. When the the recording has been completed and the drum starts making a second revolution, the recording head 141 has been shifted to the left by 510 plus 1/2 pixel pitches, the orifice No. 1 is shifted to the left by 1/2 pixel pitch from a position in which orifice No. 511 was located first, and orifice No. 2 is shifted to the left by 1/2 pixel pitch from a position in which orifice 512 was located first.

Next, the numbers of ink droplets discharged from orifices Nos. 1, 2, 511 and 512 are four, and the second image area and the latter are formed.

When the last image area is formed, the numbers of ink droplets discharged from only orifices Nos. 1 and 2 are four. Thus, recording of all the image areas has been completed.

The state of pixels in a boundary between each image area in embodiment 6 is shown in Fig. 18.

According to the present invention, the unevenness of image density, a "black stripe" or a "white stripe", which is generated in a vicinity of a boundary between each recorded image area at each main-scanning, is markedly reduced by simple control, and hence the image quality is improved in the vicinity of the boundary between each image area.

(Further Description)

The present invention achieves distinct effect when applied to a recording head or a recording apparatus which has means for generating thermal energy such as electrothermal transducers or laser light, and which causes changes in the ink by the thermal energy so as to eject ink. This is because such a system can achieve a high density and high resolution recording.

A typical structure and operational principl thereof is disclosed in U.S. patent Nos. 4,723,129 and 4,740,796, and it is preferable to use this basic principle to implement such a system. Although this system can be applied either to on-demand type or continuous type ink jet recording systems, it is particularly suitable for the on-demand type apparatus. This is because the on-demand type apparatus has electrothermal transducers, each disposed on a sheet or liquid passage that retains liquid (ink), and operates as follows: first, one or more drive signals are applied to the electrothermal transducers to cause thermal energy corresponding to recording information; second, the thermal energy induces sudden temperature rise that exceeds the nucleate boiling so as to cause the film boiling on heating portions of the recording head; and third, bubbles are grown in the liquid (ink) corresponding to the drive signals. By using the growth and collapse of the bubbles, the ink is expelled from at least one of the ink ejection orifices of the head to form one or more ink drops. The drive signal in the form of a pulse is preferable because the growth and collapse of the bubbles can be achieved instantaneously and suitably by this form of drive signal. As a drive signal in the form of a pulse, those described in U.S. patent Nos. 4,463,359 and 4,345,262 are preferable. In addition, it is preferable that the rate of temperature rise of the heating portions described in U.S. patent No. 4,313,124 be adopted to achieve better recording.

U.S. patent Nos. 4,558,333 and 4,459,600 disclose the following structure of a recording head, which is incorporated to the present invention: this structure includes heating portions disposed on bent portions in addition to a combination of the ejection orifices, liquid passages and the electrothermal transducers disclosed in the above patents. Moreover, the present invention can be applied to structures disclosed in Japanese Patent Application Laying-open Nos. 123670/1984 and 138461/1984 in order to achieve similar effects. The former discloses a structure in which a slit common to all the thermoelectric transducers is used as ejection orifices of the electrothermal transducers, and the latter discloses a structure in which openings for absorbing pressure waves caused by thermal energy are formed corresponding to the ejection orifices. Thus, irrespective of the type of the recording head, the present invention can achieve recording positively and effectively.

In addition, the present invention can be applied to various serial type recording heads: a recording head fixed to the main assembly of a recording apparatus; a conveniently replaceable chip type recording head which, when loaded on the main assembly of a recording apparatus, is electrically connected to the main assembly, and is supplied with ink therefrom; and a cartridge type recording head integrally including an ink reservoir.

It is further preferable to add a recovery system, or a preliminary auxiliary system for a recording head as a constituent of the recording apparatus becaus they serve t make th effect of the pr sent invention more

reliable. As examples of the recovery system, are a capping means and a cleaning means for the recording head, and a pressure or suction means for the recording head. As examples of the preliminary auxiliary system, are a preliminary heating means utilizing electrothermal transducers or a combination of other heater elements and the electrothermal transducers, and a means for carrying out preliminary ejection of ink independently of the ejection for recording. These systems are effective for reliable recording.

The number and type of recording heads to be mounted on a recording apparatus can be also changed. For example, only one recording head corresponding to a single color ink, or a plurality of recording heads corresponding to a plurality of inks different in color or concentration can be used. In other words, the present invention can be effectively applied to an apparatus having at least one of the monochromatic, multicolor and full-color modes. Here, the monochromatic mode performs recording by using only one major color such as black. The multi-color mode carries out recording by using different color inks, and the full-color mode performs recording by color mixing.

Furthermore, although the above-described embodiments use liquid ink, inks that are liquid when the recording signal is applied can be used: for example, inks can be employed that solidify at a temperature lower than the room temperature and are softened or liquefied in the room temperature. This is because in the ink jet system, the ink is generally temperature adjusted in a range of 30°C - 70°C so that the viscosity of the ink is maintained at such a value that the ink can be ejected reliably.

In addition, the present invention can be applied to such apparatus where the ink is liquefied just before the ejection by the thermal energy as follows so that the ink is expelled from the orifices in the liquid state, and then begins to solidify on hitting the recording medium, thereby preventing the ink evaporation: the ink is transformed from solid to liquid state by positively utilizing the thermal energy which would otherwise cause the temperature rise; or the ink, which is dry when left in air, is liquefied in response to the thermal energy of the recording signal. In such cases, the ink may be retained in recesses or through holes formed in a porous sheet as liquid or solid substances so that the ink faces the electrothermal transducers as described in Japanese Patent Application Laying-open Nos. 56847/1979 or 71260/1985. The present invention is most effective when it uses the film boiling phenomenon to expel the ink.

Furthermore, the ink jet recording apparatus of the present invention can be employed not only as an image output terminal of an information processing device such as a computer, but also as an output device of a copying machine including a reader, as an output device of a facsimile apparatus having a transmission and receiving function, and as an output device of an optical disc apparatus for recording and/or reproducing information into and/or from an optical disc. These apparatus requires means for outputting processed information in the form of hard copy.

The present invention has been described in detail with respect to preferred embodiments, and it will now be apparent from the foregoing to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and it is the intention, therefore, in the appended claims to cover all such changes and modifications as fall within the true spirit of the invention.

Claims

1. A method of recording an image on a recording medium using a recording head (1) having at least one array of ejection orifices for ejecting ink to record pixels of the image on the recording medium, which method comprises recording one portion of the image by effecting relative scanning of the recording head (1) and the recording medium in a main scanning direction extending transversely of the ejection orifice array; effecting relative movement of the recording head (1) and the recording medium in a sub-scanning direction extending perpendicular to the main scan direction; and then recording another image portion by effecting relative movement between the recording head (1) and the recording medium in the main scanning direction while causing the ejection orifice to eject ink, the relative movement between the recording head and the recording medium in the sub-scanning direction between the main scans causing the area scanned by the succeeding main scan to overlap partially the area scanned by the preceding main scan, characterised by recording tonal gradations in the image by controlling the area of each pixel by controlling the amount of ink ejected by the recording head to form that pixel and generating a required tonal gradation in the area of overlap by controlling the ejection of ink from the ejection orifices scanning over the area of overlap so that, during the first main scan, the amount of ink ejected by the ejection orifices scanning the eventual area of overlap is progressively reduced in the sub-scanning direction and, during the succeeding main scan, the amount of ink ejected by the ejection orifices scanning over the area of overlap is progressively increased, so that the total quantity of ink ejected for the area of overlap during the two scans corresponds to the amount of ink which would have been ejected in a single scan of a non-overlap area.

2. A method according to claim 1, wherein the amount of ink deposited for a pixel is increased by increasing the number of ejection orifice ink discharges for the pixel.

3. A method according to claim 1, wherein the amount

of ink deposited for a pixel corresponds to the number of ejection orifice ink discharges for that pixel.

4. A method according to claim 1, 2 or 3, wherein the amount of relative movement between the recording head and the recording medium in the sub-scan direction is set to be a non-integer multiple of the spacing of the ejection orifices in the sub-scan direction.

5. A method according to any one of the preceding claims, which comprises using a thermal ink jet recording head.

6. A method according to any one of the preceding claims for multi-colour recording.

7. Ink jet recording apparatus for recording an image on a recording medium using a recording head (1) having at least one array of ejection orifices for ejecting ink to record pixels of the image on the recording medium, which apparatus comprises means (174, 175A-B, 207, 209) for effecting relative scanning of the recording head (1) and the recording medium in a main scanning direction extending transversely of the ejection orifice array; means (211, 213) for effecting relative movement of the recording head (1) and the recording medium in a sub-scanning direction extending perpendicular to the main scan direction following a main scan; and control means (201) adapted to cause respective portions of the image to be recorded in successive main scans and to cause the area scanned by the succeeding main scan to overlap partially the area scanned by the preceding main scan, characterised in that, in order to record tonal gradations in an image, the control means (201) is adapted to control the area of each pixel by controlling the amount of ink ejected by the recording head to form that pixel and to generate a required tonal gradation in the area of overlap by controlling the ejection of ink from the ejection orifices scanning over the area of overlap so that, during the first main scan, the amount of ink ejected by the ejection orifices scanning the eventual area of overlap is progressively reduced in the sub-scanning direction and, during the succeeding main scan, the amount of ink ejected by the ejection orifices scanning over the area of overlap is progressively increased, so that the total quantity of ink ejected for the area of overlap during the two scans corresponds to the amount of ink which would have been ejected in a single scan of a non-overlap area.

8. Apparatus according to claim 7, wherein the control means (201) is adapted to incr as the amount of ink deposited for a pixel by increasing the number of ejection orifice ink discharges for the pixel.

9. Apparatus according to claim 7, wherein the control means (201) is adapted to control th amount of ink deposited for a pixel by controlling the number of ejection orifice ink discharges for that pixel.

10. Apparatus according to claim 7, 8 or 9, wherein the amount of relative movement between the recording head and the recording medium in the sub-scan direction is set by the control means to be a non-integer multiple of the spacing of the ejection orifices in the sub-scan direction.

11. Apparatus according to claim 7, 8, 9 or 10, wherein the recording head is a thermal ink jet head.

12. Apparatus according to any one of claims 7 to 11, wherein the apparatus is adapted for colour recording.

13. Apparatus according to any one of claims 7 to 12 and including recovery means for carrying out recovery processing on the recording head.

14. Ink jet recording apparatus according to any one of claims 7 to 13 and incorporated in a facsimile machine, or a copying machine or a computer terminal.

Patentansprüche

1. Verfahren zum Aufzeichnen eines Bildes auf einem Aufzeichnungsmedium unter Verwendung eines Aufzeichnungskopfes (1) mit zumindest einer Anordnung von Ausspritzöffnungen zum Ausspritzen von Tinte, um Bildpunkte des Bildes auf dem Aufzeichnungsmedium aufzuzeichnen, wobei das Verfahren folgende Schritte aufweist: Aufzeichnen eines Abschnittes des Bildes durch Bewirken eines Relativabtastens des Aufzeichnungskopfes (1) und des Aufzeichnungsmediums in einer Hauptabtastrichtung, die sich quer zu der Ausspritzöffnungsanordnung erstreckt; Bewirken einer Relativbewegung des Aufzeichnungskopfes (1) und des Aufzeichnungsmediums in einer Nebenabtastrichtung, die sich senkrecht zu der Hauptabtastrichtung erstreckt; und danach Aufzeichnen eines anderen Bildabschnittes durch Bewirken einer Relativbewegung zwischen dem Aufzeichnungskopf (1) und dem Aufzeichnungsmedium in der Hauptabtastrichtung, während verursacht wird, daß die Ausspritzöffnung Tinte ausspritzt, wobei die Relativbewegung zwischen dem Aufzeichnungskopf und dem Aufzeichnungsmedium in der Nebenabtastrichtung zwischen den Hauptabtastungen verursacht, daß der Bereich, der durch das nachfolgende Hauptabtasten abgetastet wird, teilweise den Bereich überdeckt, der durch das vorhergehende Hauptabtasten abgetastet wurde,
gekennzeichnet durch

Aufzeichnen von Tonabstufungen in dem Bild durch Steu rn der Fläche jedes Bildpunktes durch Steuern der Tintenmenge, die durch den Aufzeichnungskopf ausgespritzt wird, um jenen Bildpunkt zu bilden und eine erforderliche Tonabstufung in dem Überdeckungsbereich zu erzeugen, indem das Ausspritzen von Tinte aus den Ausspritzöffnungen gesteuert wird, die über dem Überdeckungsbereich abtasten, so daß während des ersten Hauptabtastens die Tintenmenge, die durch die Ausspritzöffnungen ausgespritzt wird, die den eventuellen Überdeckumgsbereich abtasten, in der Nebenabtastrichtung allmählich abnimmt und während des nachfolgenden Hauptabtastens die Tintenmenge, die durch die Ausspritzöffnungen ausgespritzt wird, die über dem Überdeckungsbereich abtasten, allmählich zunimmt, so daß die Gesamttintenmenge, die für den Überdeckungsbereich während der beiden Abtastungen ausgespritzt wird, der Tintenmenge entspricht, die bei einem einzelnen Abtasten eines überdeckungsfreien Bereiches ausgespritzt worden wäre.

2. Verfahren nach Anspruch 1, wobei die für einen Bildpunkt ausgeschiedene Tintenmenge zunimmt, indem die Anzahl von Tintenausstößen der Ausspritzöffnung für den Bildpunkt zunimmt.

3. Verfahren nach Anspruch 1, wobei die für einen Bildpunkt ausgeschiedene Tintenmenge der Anzahl von Tintenausstößen der Ausspritzöffnung für jenen Bildpunkt entspricht.

4. Verfahren nach Anspruch 1, 2 oder 3, wobei der Betrag der Relativbewegung zwischen dem Aufzeichnungskopf und dem Aufzeichnungsmedium in der Nebenabtastrichtung so eingestellt ist, daß er ein nichtganzzahliges Vielfaches des Abstandes der Ausspritzöffnungen in der Nebenabtastrichtung ist.

5. Verfahren nach einem der vorherigen Ansprüche, das ein Verwenden eines thermischen Tintenstrahlaufzeichnungskopfes aufweist.

6. Verfahren nach einem der vorherigen Ansprüche zum Vielfarbenaufzeichnen.

7. Tintenstrahlaufzeichnungsgerät zum Aufzeichnen eines Bildes auf einem Aufzeichnungsmedium unter Verwendung eines Aufzeichnungskopfes (1) mit zumindest einer Anordnung von Ausspritzöffnungen zum Ausspritzen von Tinte, um Bildpunkte des Bildes auf dem Aufzeichnungsmedium aufzuzeichnen, wobei das Gerät folgendes aufweist: eine Einrichtung (174, 175A-B, 207, 209) zum Bewirken eines Relativabtastens des Aufzeichnungskopfes (1) und des Aufzeichnungsmediums in einer Hauptabtastrichtung, die sich quer zu der Ausspritzöffnungsanordnung erstreckt; eine Einrichtung (211, 213) zum Bewirken einer einem Hauptabtasten folgenden Relativbewegung des Aufzeichnungskopfes (1) und des Aufzeichnungsmediums in einer Nebenabtastrichtung, die sich senkrecht zu der Hauptabtastrichtung erstreckt; und eine Steuereinrichtung (201) dazu angepaßt ist, daß sie verursacht, daß jeweilige Abschnitte des Bildes in aufeinanderfolgenden Hauptabtastungen aufgezeichnet werden, und verursacht, daß der Bereich, der durch das nachfolgende Hauptabtasten abgetastet wird, teilweise den Bereich überdeckt, der durch das vorhergehende Hauptabtasten abgetastet wurde,
dadurch gekennzeichnet, daß
zum Aufzeichnen von Tonabstufungen in einem Bild die Steuereinrichtung (201) dazu angepaßt ist, die Fläche jedes Bildpunktes zu steuern, indem die Tintenmenge gesteuert wird, die durch den Aufzeichnungskopf ausgespritzt wird, um jenen Bildpunkt zu bilden und eine erforderliche Tonabstufung in dem Überdeckungsbereich zu erzeugen, indem das Ausspritzen von Tinte aus den Ausspritzöffnungen gesteuert wird, die über dem Überdeckungsbereich abtasten, so daß während des ersten Hauptabtastens die Tintenmenge, die durch die Ausspritzöffnungen ausgespritzt wird, die den eventuellen Überdeckungsbereich abtasten, in der Nebenabtastrichtung allmählich zunimmt und während des nachfolgenden Hauptabtastens die Tintenmenge, die durch die Ausspritzöffnungen ausgespritzt wird, die über dem Überdeckungsbereich abtasten, allmählich zunimmt, so daß die Gesamttintenmenge, die für den Überdeckungsbereich während der beiden Abtastungen ausgespritzt wird, der Tintenmenge entspricht, die bei einem einzelnen Abtasten eines überdeckungsfreien Bereiches ausgespritzt worden wäre.

8. Gerät nach Anspruch 7, wobei die Steuereinrichtung (201) angepaßt ist, die für einen Bildpunkt ausgeschiedene Tintenmenge zu erhöhen, indem sie die Anzahl von Tintenausstößen der Ausspritzöffnung für den Bildpunkt erhöht.

9. Gerät nach Anspruch 7, wobei die Steuereinrichtung (201) angepaßt ist, die für einen Bildpunkt ausgeschiedene Tintenmenge durch Steuern der Anzahl von Tintenausstößen der Ausspritzöffnung für jenen Bildpunkt zu steuern.

10. Gerät nach Anspruch 7, 8 oder 9, wobei der Betrag der Relativbewegung zwischen dem Aufzeichnungskopf und dem Aufzeichnungsmedium in der Nebenabtastrichtung durch die Steuereinrichtung so eingestellt ist, daß er ein nichtganzzahliges Vielfaches des Abstandes der Ausspritzöffnungen in der Nebenabtastrichtung ist.

11. Gerät nach Anspruch 7, 8, 9 oder 10, wobei der Aufzeichnungskopf ein thermischer Tintenstrahlkopf ist.

12. Gerät nach einem der Ansprüche 7 bis 11, wobei das G rät zum Farbaufzeichnen angepaßt ist.

13. Gerät nach einem der Ansprüche 7 bis 12 und das eine Wiederherstellungseinrichtung zum Ausführen einer Wiederherstellungsbehandlung an dem Aufzeichnungskopf umfaßt.

14. Tintenstrahlaufzeichnungsgerät nach einem der Ansprüche 7 bis 13 und das in einem Faxgerät, einer Kopiermaschine oder einem Rechneranschluß eingebaut ist.

Revendications

1. Procédé d'enregistrement d'une image sur un support d'enregistrement en utilisant une tête d'enregistrement (1) ayant au moins un groupement d'orifices d'éjection pour éjecter de l'encre afin d'enregistrer des pixels de l'image sur le support d'enregistrement, lequel procédé consiste à enregistrer une partie de l'image en effectuant un balayage relatif de la tête d'enregistrement (1) et du support d'enregistrement dans une direction de balayage principal s'étendant transversalement au groupement d'orifices d'éjection ; à effectuer un mouvement relatif de la tête d'enregistrement (1) et du support d'enregistrement dans une direction de balayage secondaire s'étendant perpendiculairement à la direction de balayage principal ; et à enregistrer ensuite une autre partie d'image en effectuant un mouvement relatif entre la tête d'enregistrement (1) et le support d'enregistrement dans la direction de balayage principal tout en amenant l'orifice d'éjection à éjecter de l'encre, le mouvement relatif entre la tête d'enregistrement et le support d'enregistrement dans la direction du balayage secondaire, entre les balayages principaux, amenant la zone balayée par le balayage prinicipal suivant à recouvrir partiellement la zone balayée par le bayage principal précédent, caractérisé par l'enregistrement de gradations tonales dans l'image en réglant l'aire de chaque pixel par un réglage de la quantité d'encre éjectée par la tête d'enregistrement pour former ce pixel et la génération d'une gradation tonale demandée dans la zone de recouvrement en commandant l'éjection d'encre à partir des orifices d'éjection effectuant un balayage au-dessus de la zone de recouvrement afin que, pendant le premier balayage principal, la quantité d'encre éjectée par les orifices d'éjection balayant la zone éventuelle de recouvrement soit progressivement réduite dans la direction de balayage secondaire et que, pendant le balayage principal suivant, la quantité d'encre éjecté par les orifices d'éjection effectuant un balayage au-dessus de la zone d recouvrement soit progressivement augmentée, pour que la quantité totale d'encre éjecté pour la zone de recouvrement pendant les deux balayages corresponde à la quantité d'encre qui aurait été éjectée en un seul balayage d'une zone de non-recouvrement.

2. Procédé selon la revendication 1, dans lequel la quantité d'encre déposée pour un pixel est augmentée par une augmentation du nombre de décharges d'encre par l'orifice d'éjection pour le pixel.

3. Procédé selon la revendication 1, dans lequel la quantité d'encre déposée pour un pixel correspond au nombre de décharges d'encre par l'orifice d'éjection pour ce pixel.

4. Procédé selon la revendication 1, 2 ou 3, dans lequel l'amplitude du mouvement relatif entre la tête d'enregistrement et le support d'enregistrement dans la direction de balayage secondaire est établie de façon à être un multiple non entier de l'espacement des orifices d'éjection dans la direction du balayage secondaire.

5. Procédé selon l'une quelconque des revendications précédentes, qui comprend l'utilisation d'une tête d'enregistrement à jets d'encre produits thermiquement.

6. Procédé selon l'une quelconque des revendications précédentes pour un enregistrement en couleurs multiples.

7. Appareil d'enregistrement par jets d'encre destiné à enregistrer une image sur un support d'enregistrement en utilisant une tête d'enregistrement (1) ayant au moins un groupement d'orifices d'éjection pour éjecter de l'encre afin d'enregistrer les pixels de l'image sur le support d'enregistrement, lequel appareil comporte des moyens (174, 175A-B, 207, 209) pour effectuer un balayage relatif de la tête d'enregistrement (1) et du support d'enregistrement dans une direction de balayage principal s'étendant transversalement au groupement d'orifices d'éjection ; des moyens (211, 213) destinés à effectuer un mouvement relatif de la tête d'enregistrement (1) et du support d'enregistrement dans une direction de balayage secondaire s'étendant perpendiculairement à la direction du balayage principal, à la suite d'un balayage principal ; et des moyens de commande (201) conçus pour provoquer l'enregistrement de parties respectives de l'image dans des balayages principaux respectifs et pour amener la zone balayée par le balayage principal suivant à recouvrir partiellement la zone balayée par le balayage principal précédent, caractérisé en ce

que, pour enregistrer des gradations tonales dans une image, les moyens de commande (201) sont conçus pour régler l'aire de chaque pixel en réglant la quantité d'encre éjectée par la tête d'enregistrement pour former ce pixel, et pour générer une gradation tonale demandée dans la zone de recouvrement en commandant l'éjection d'encre à partir des orifices d'éjection effectuant un balayage au-dessus de la zone de recouvrement afin que, pendant le premier balayage principal, la quantité d'encre éjectée par les orifices d'éjection balayant la zone éventuelle de recouvrement soit diminuée progressivement dans la direction de balayage secondaire et que, pendant le balayage principal suivant, la quantité d'encre éjectée par les orifices d'éjection effectuant un balayage au-dessus de la zone de recouvrement soit progressivement augmentée, pour que la quantité totale d'encre éjectée pour la zone de recouvrement entre les deux balayages corresponde à la quantité d'encre qui aurait été éjectée en un seul balayage d'une zone de non-recouvrement.

8. Appareil selon la revendication 7, dans lequel les moyens de commande (201) sont conçus pour augmenter la quantité d'encre déposée pour un pixel par augmentation du nombre de décharges d'encre par l'orifice d'éjection pour le pixel.

9. Appareil selon la revendication 7, dans lequel les moyens de commande (201) sont conçus pour régler la quantité d'encre déposée pour un pixel en réglant le nombre de décharges d'encre par l'orifice d'éjection pour ce pixel.

10. Appareil selon la revendication 7, 8 ou 9, dans lequel l'amplitude du mouvement relatif entre la tête d'enregistrement et le support d'enregistrement dans la direction du balayage secondaire est établie par les moyens de commande de façon à être un multiple non entier de l'espacement des orifices d'éjection dans la direction du balayage secondaire.

11. Appareil selon la revendication 7, 8, 9 ou 10, dans lequel la tête d'enregistrement est une tête à jets d'encre produits thermiquement.

12. Appareil selon l'une quelconque des revendications 7 à 11, dans lequel l'appareil est conçu pour un enregistrement en couleurs.

13. Appareil selon l'une quelconque des revendications 7 à 12, et comprenant des moyens de restauration destinés à effectuer un traitement de restauration sur la tête d'enregistrement.

14. Appareil d'enregistrement à jets d'encre selon l'une quelconque d s revendications 7 à 13 et incorporé dans une machine de télécopie ou une machine de copie ou un terminal d'ordinateur.

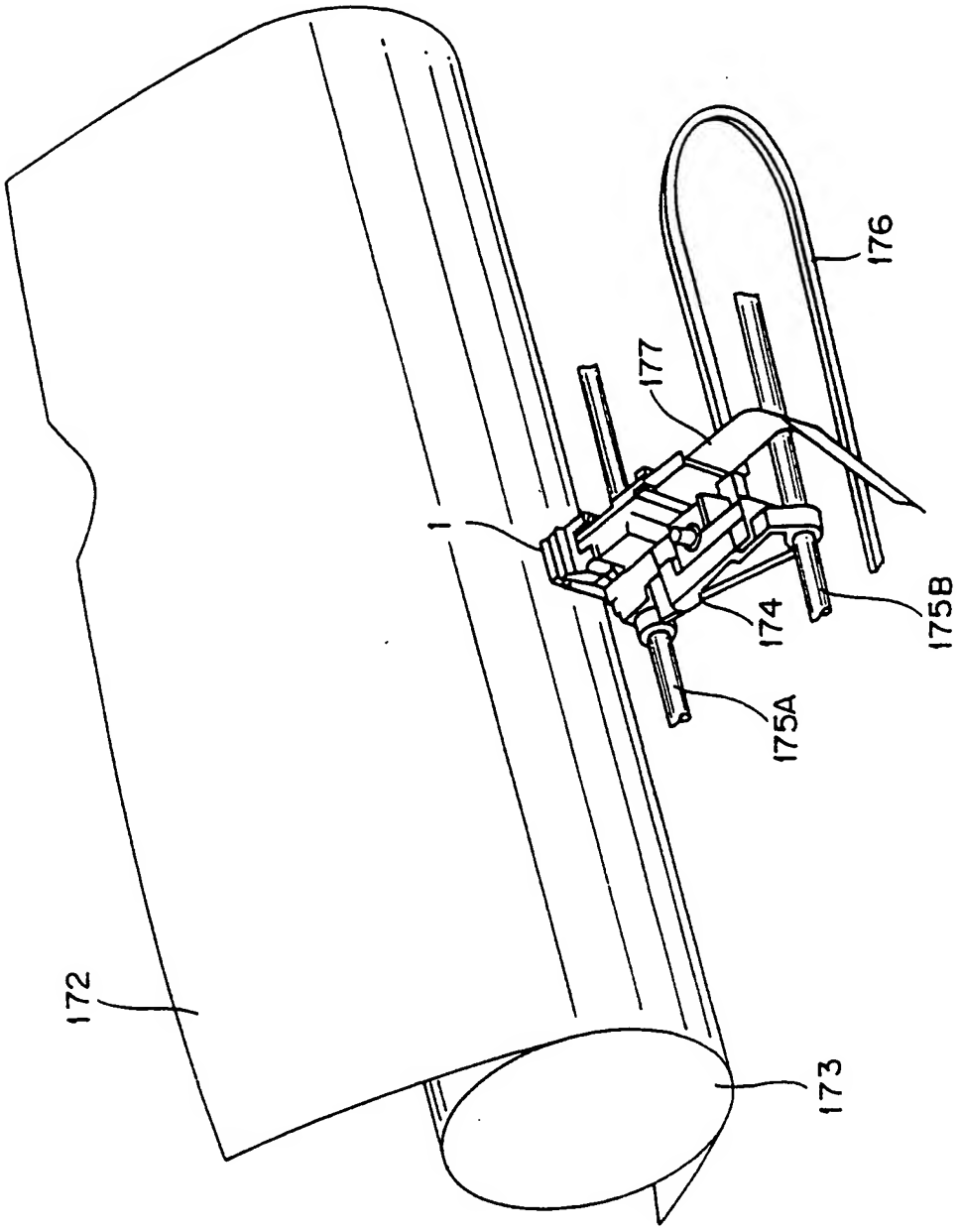


FIG.1

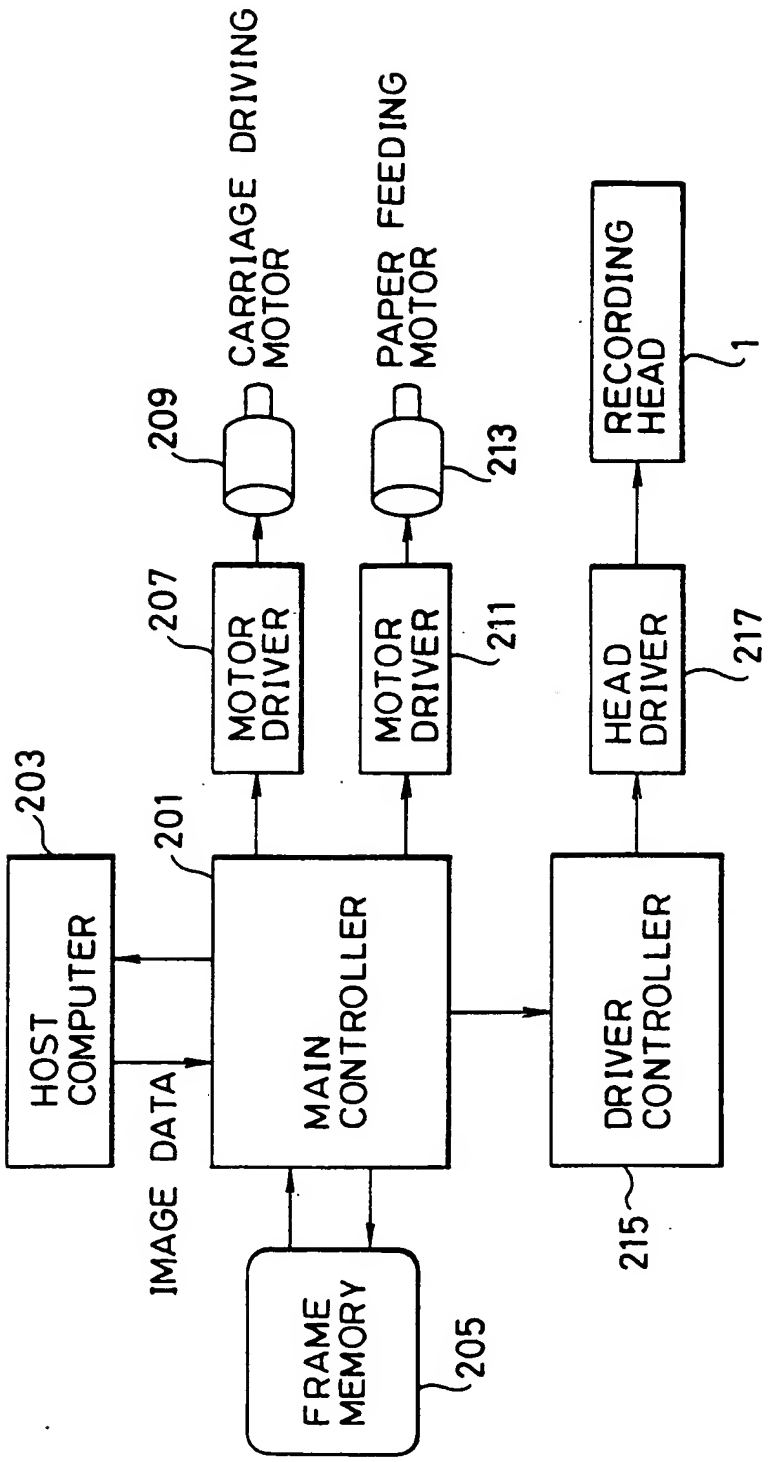

HOST COMPUTER
203
IMAGE DATA
MAIN CONTROLLER
201
MOTOR DRIVER
207
CARRIAGE DRIVING MOTOR
209
MOTOR DRIVER
211
PAPER FEEDING MOTOR
213
FRAME MEMORY
205
DRIVER CONTROLLER
215
HEAD DRIVER
217
RECORDING HEAD
1

FIG. 2

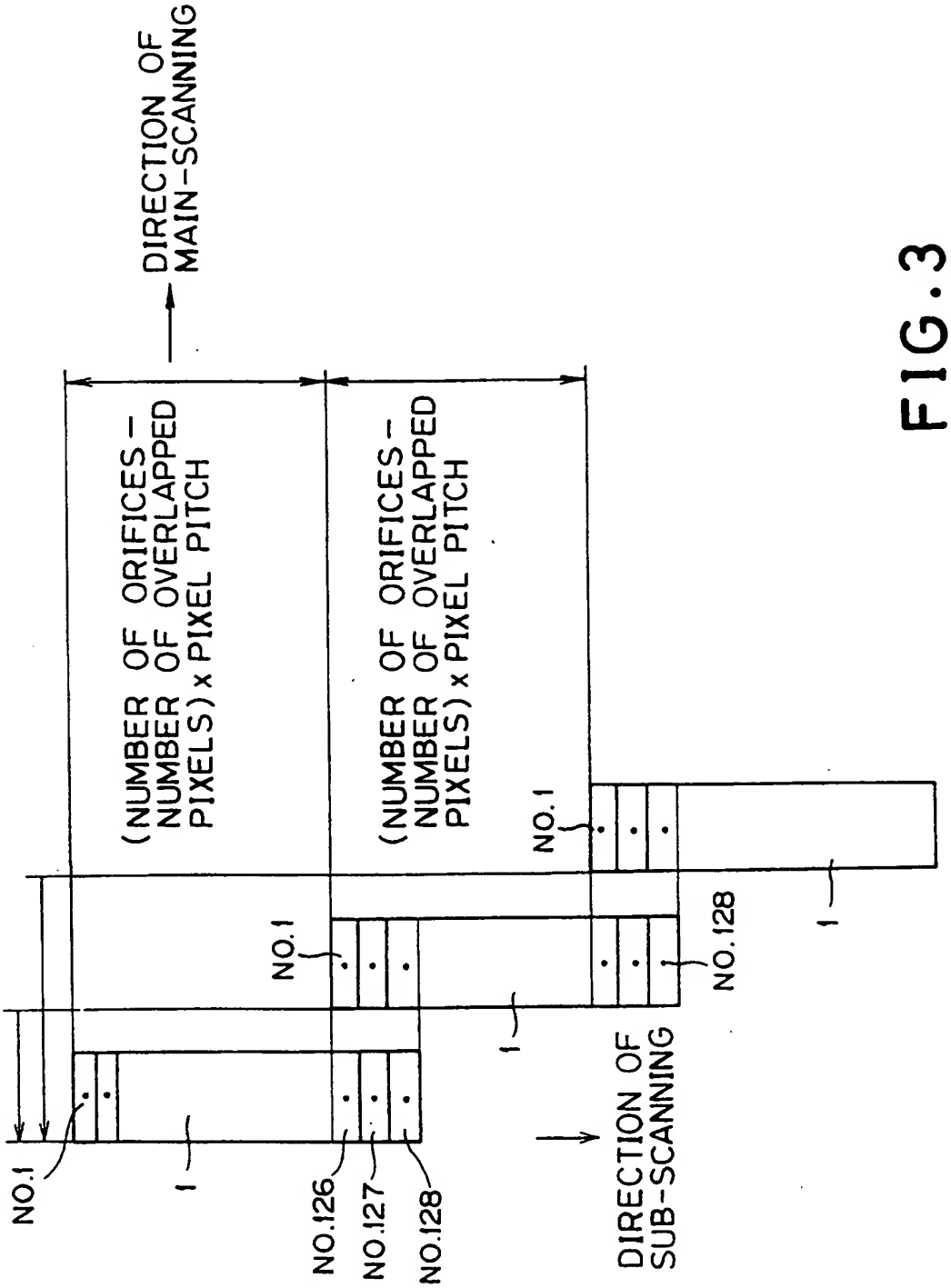

DIRECTION OF MAIN-SCANNING
(NUMBER OF ORIFICES - NUMBER OF OVERLAPPED PIXELS) x PIXEL PITCH
(NUMBER OF ORIFICES - NUMBER OF OVERLAPPED PIXELS) x PIXEL PITCH
NO.1
NO.126
NO.127
NO.128
NO.1
NO.128
NO.1
1
1
1
DIRECTION OF SUB-SCANNING

FIG.3

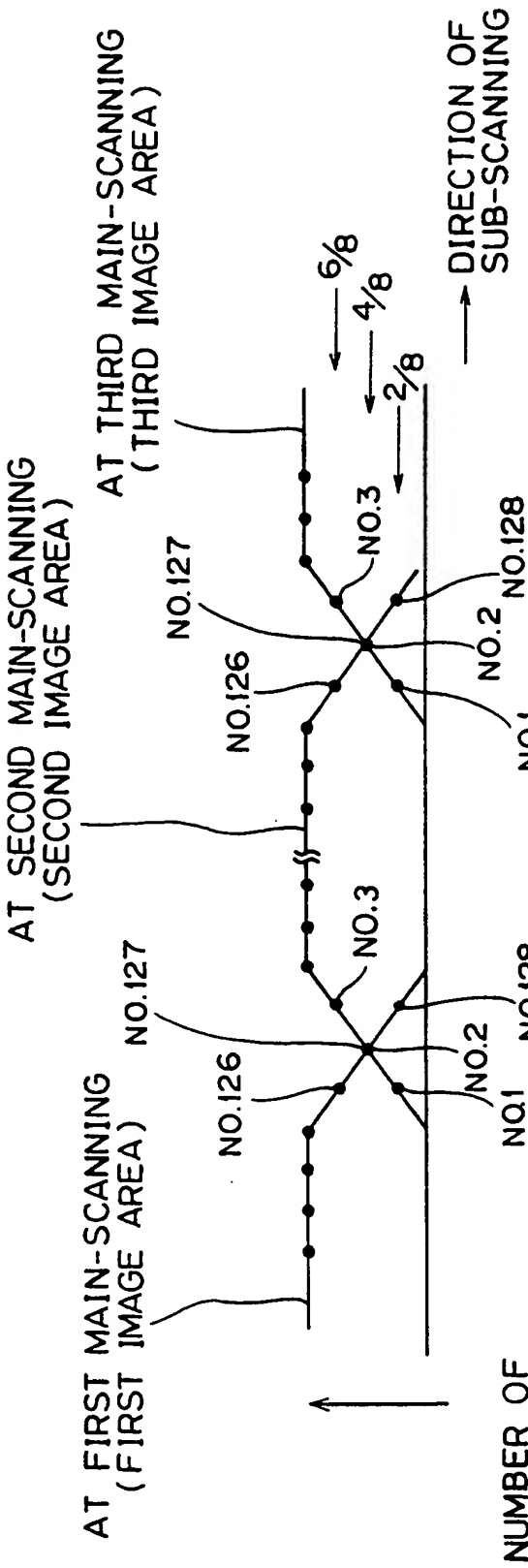

AT FIRST MAIN-SCANNING
(FIRST IMAGE AREA)
AT SECOND MAIN-SCANNING
(SECOND IMAGE AREA)
AT THIRD MAIN-SCANNING
(THIRD IMAGE AREA)
NO.1
NO.2
NO.3
NO.126
NO.127
NO.128
6/8
4/8
2/8
DIRECTION OF
SUB-SCANNING
NUMBER OF
INK DROPLETS
(DENSITY)

FIG.4

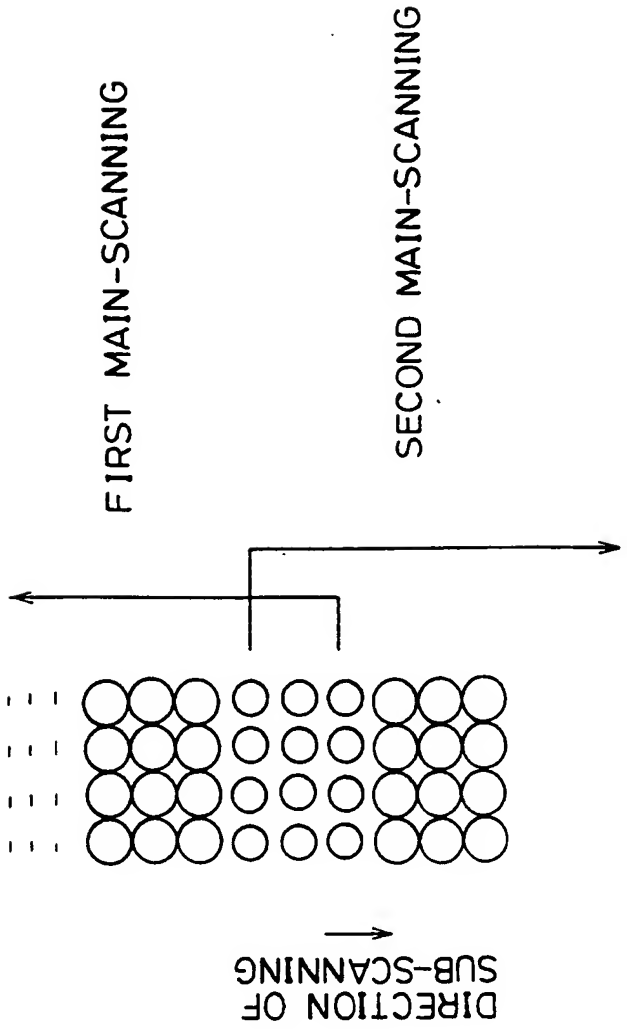

FIRST MAIN-SCANNING
SECOND MAIN-SCANNING
DIRECTION OF SUB-SCANNING

FIG.5

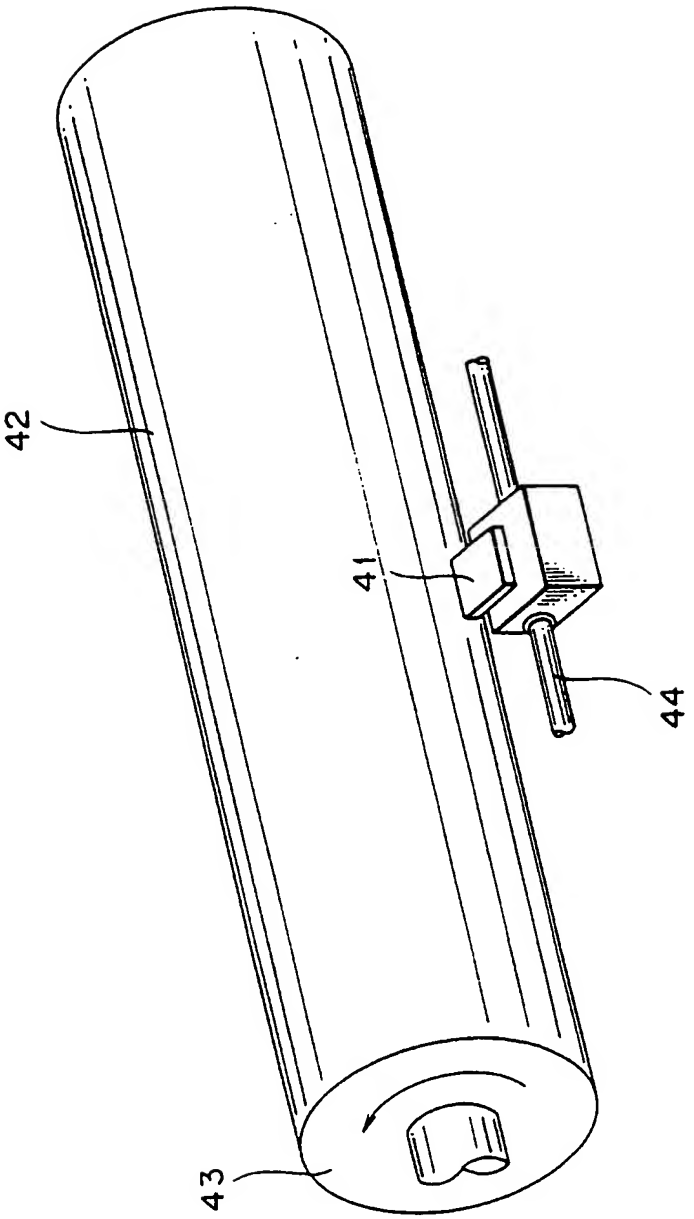


FIG.6

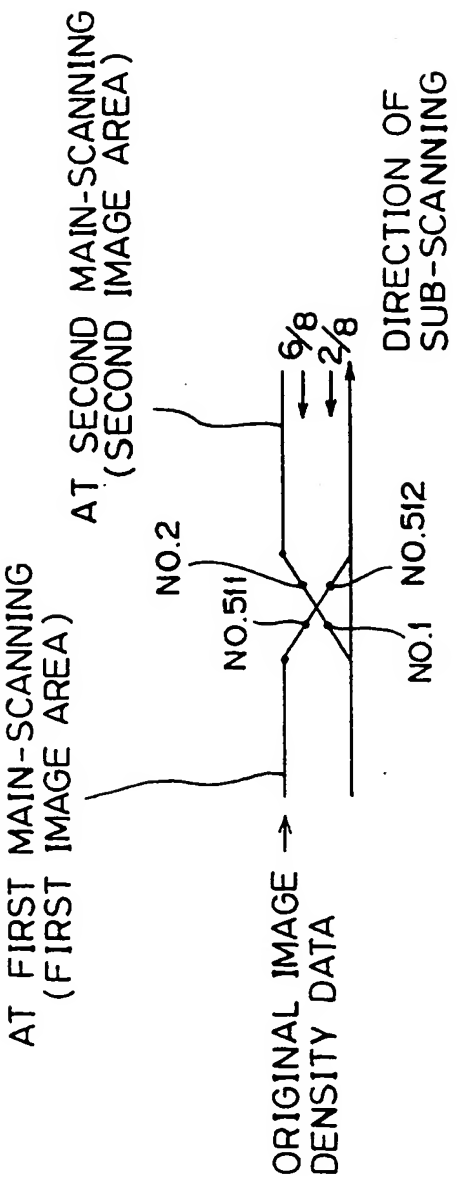

AT FIRST MAIN-SCANNING (FIRST IMAGE AREA)
AT SECOND MAIN-SCANNING (SECOND IMAGE AREA)
NO.2
NO.511
NO.1
NO.512
6/8
2/8
ORIGINAL IMAGE DENSITY DATA
DIRECTION OF SUB-SCANNING

FIG.7

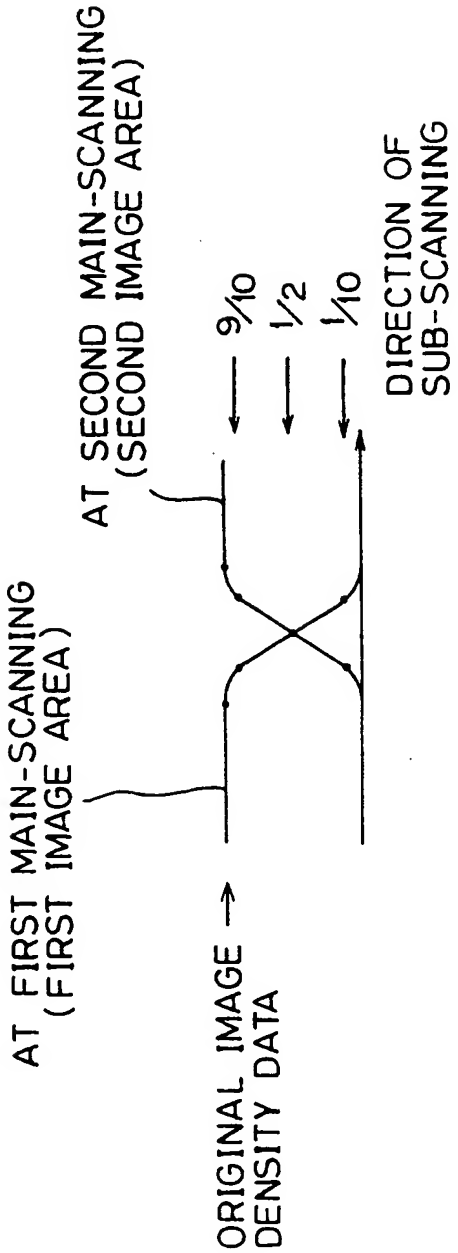

AT FIRST MAIN-SCANNING (FIRST IMAGE AREA)
AT SECOND MAIN-SCANNING (SECOND IMAGE AREA)
9/10
1/2
1/10
ORIGINAL IMAGE DENSITY DATA
DIRECTION OF SUB-SCANNING

FIG.8

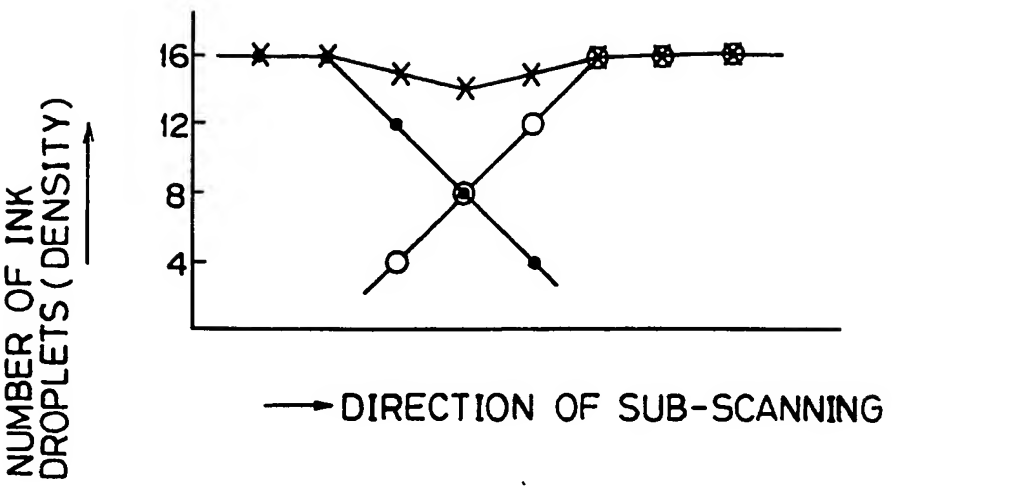

NUMBER OF INK DROPLETS (DENSITY)
16
12
8
4
DIRECTION OF SUB-SCANNING
NUMBER OF INK DROPLETS AT FIRST MAIN-SCANNING
NUMBER OF INK DROPLETS AT SECOND MAIN-SCANNING
ACTUAL DENSITY VALUE BY RECORDING AT FIRST AND SECOND MAIN-SCANNING

FIG.9

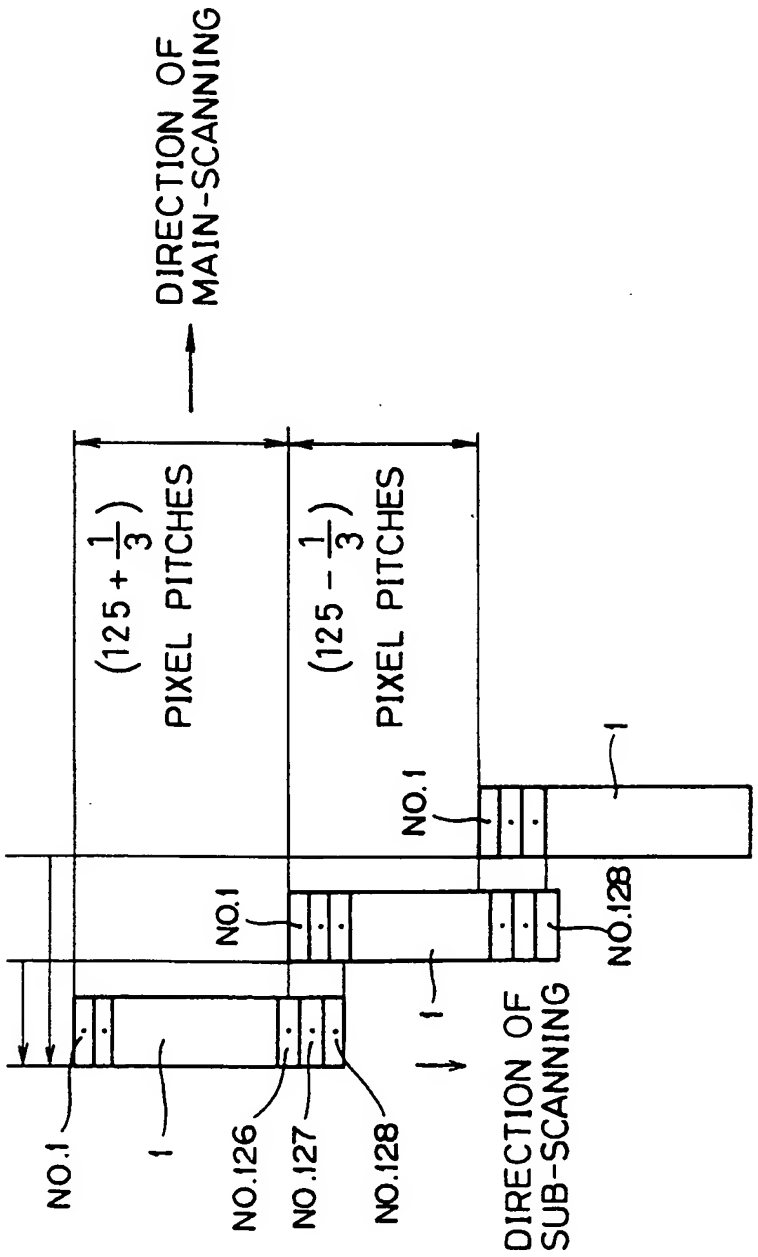

DIRECTION OF MAIN-SCANNING
(125 + 1/3) PIXEL PITCHES
(125 - 1/3) PIXEL PITCHES
NO.1
1
NO.126
NO.127
NO.128
NO.1
1
NO.1
NO.128
1
DIRECTION OF SUB-SCANNING

FIG.10

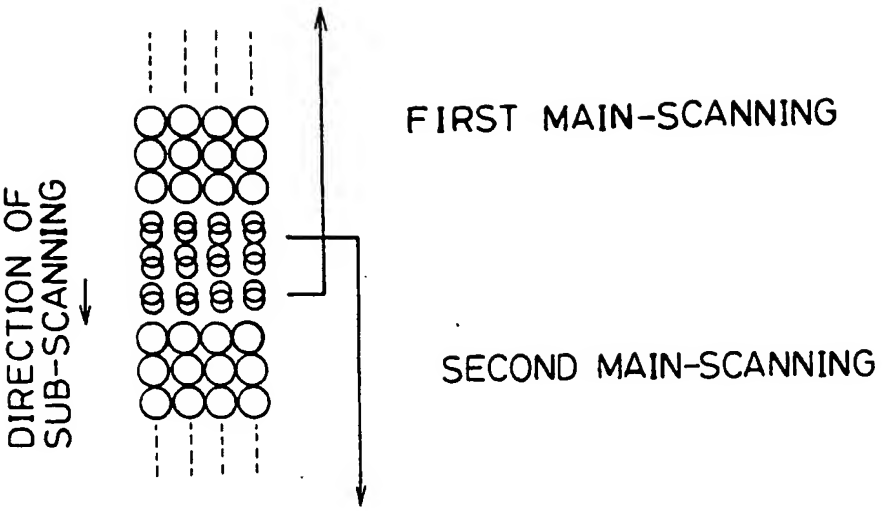

FIRST MAIN-SCANNING
DIRECTION OF SUB-SCANNING
SECOND MAIN-SCANNING

FIG.11

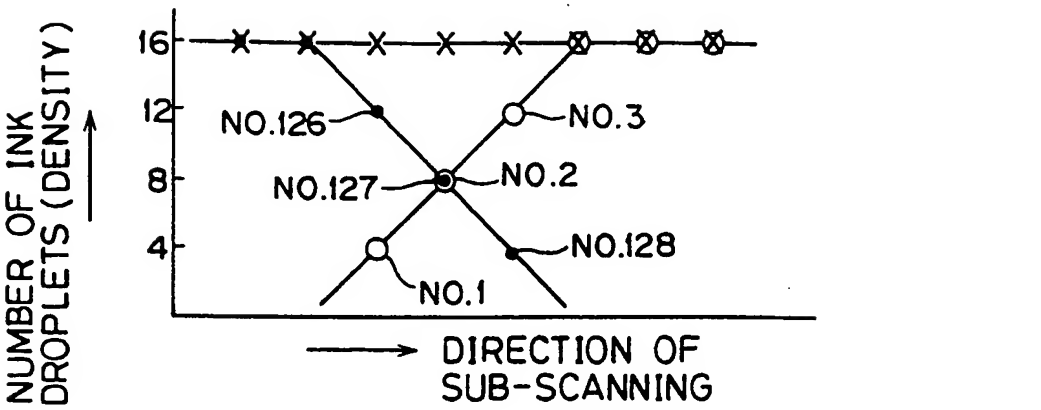

NUMBER OF INK DROPLETS (DENSITY)
16
12
8
4
NO.126
NO.3
NO.127
NO.2
NO.128
NO.1
DIRECTION OF SUB-SCANNING
NUMBER OF INK DROPLETS AT FIRST MAIN-SCANNING
NUMBER OF INK DROPLETS AT SECOND MAIN-SCANNING
DENSITY VALUE BY RECORDING AT FIRST AND SECOND MAIN SCANNING

FIG. 12

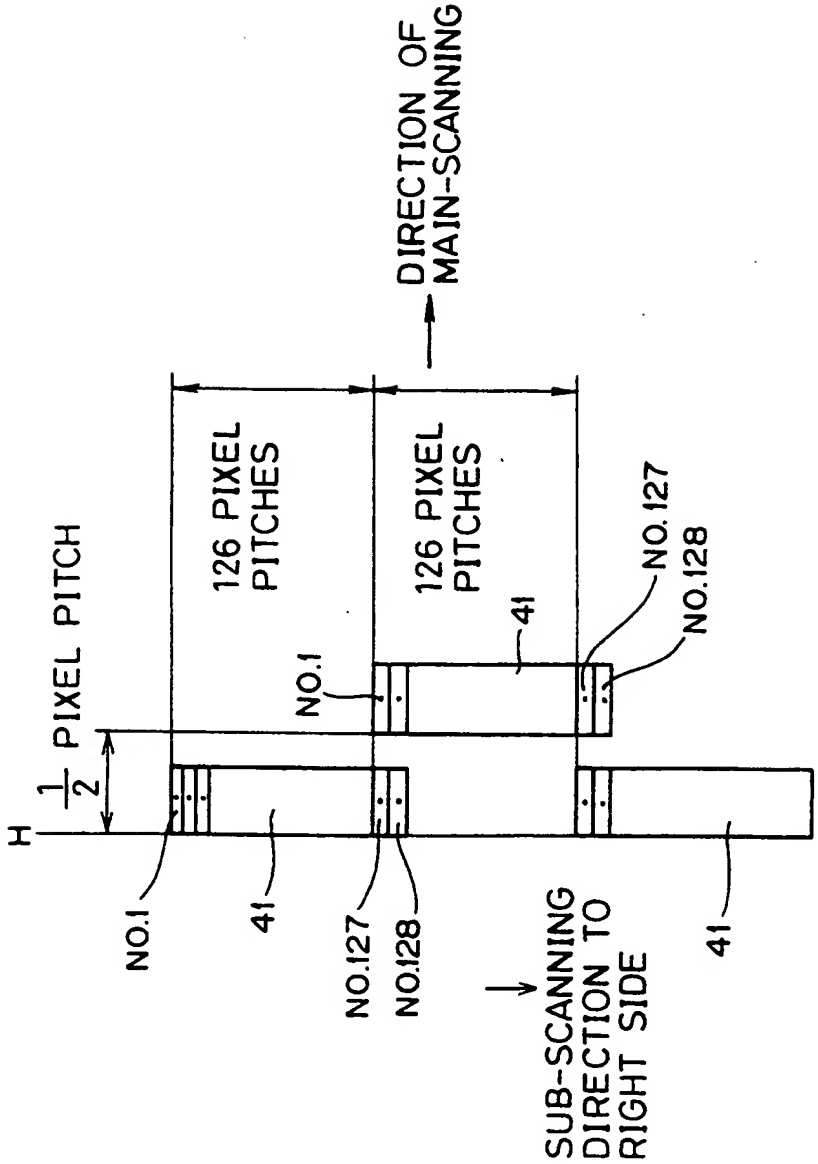
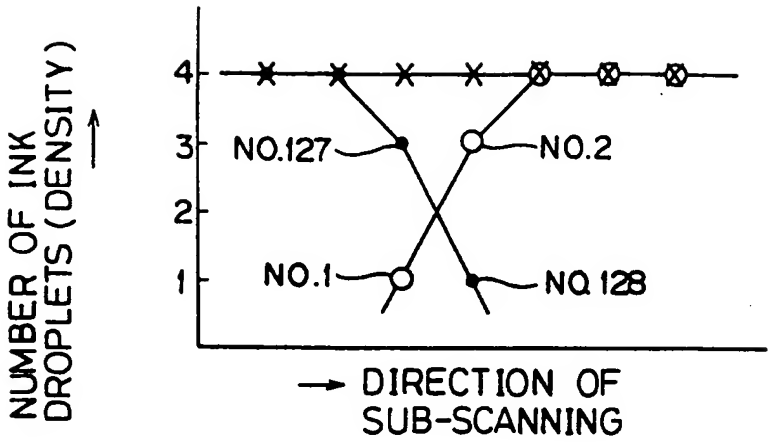

DIRECTION OF MAIN-SCANNING
126 PIXEL PITCHES
126 PIXEL PITCHES
H
1/2 PIXEL PITCH
NO.1
41
NO.127
NO.128
NO.1
41
NO.127
NO.128
41
SUB-SCANNING DIRECTION TO RIGHT SIDE

FIG.13



—●— NUMBER OF INK DROPLETS AT FIRST MAIN-SCANNING

—○— NUMBER OF INK DROPLETS AT SECOND MAIN-SCANNING

—×— DENSITY VALUE BY RECORDING AT FIRST AND SECOND MAIN-SCANNING

FIG. 14

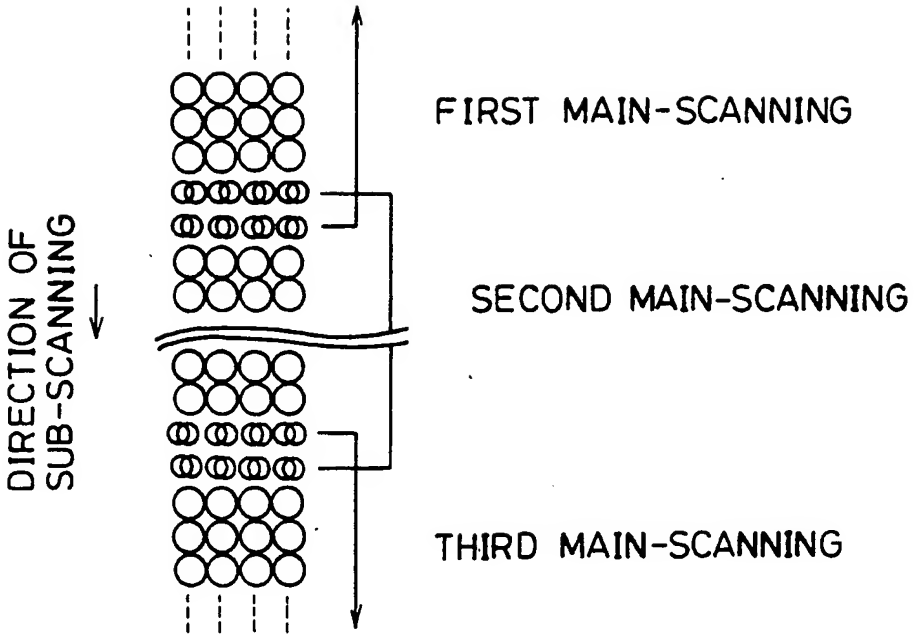

FIRST MAIN-SCANNING
SECOND MAIN-SCANNING
THIRD MAIN-SCANNING
DIRECTION OF SUB-SCANNING

FIG. 15

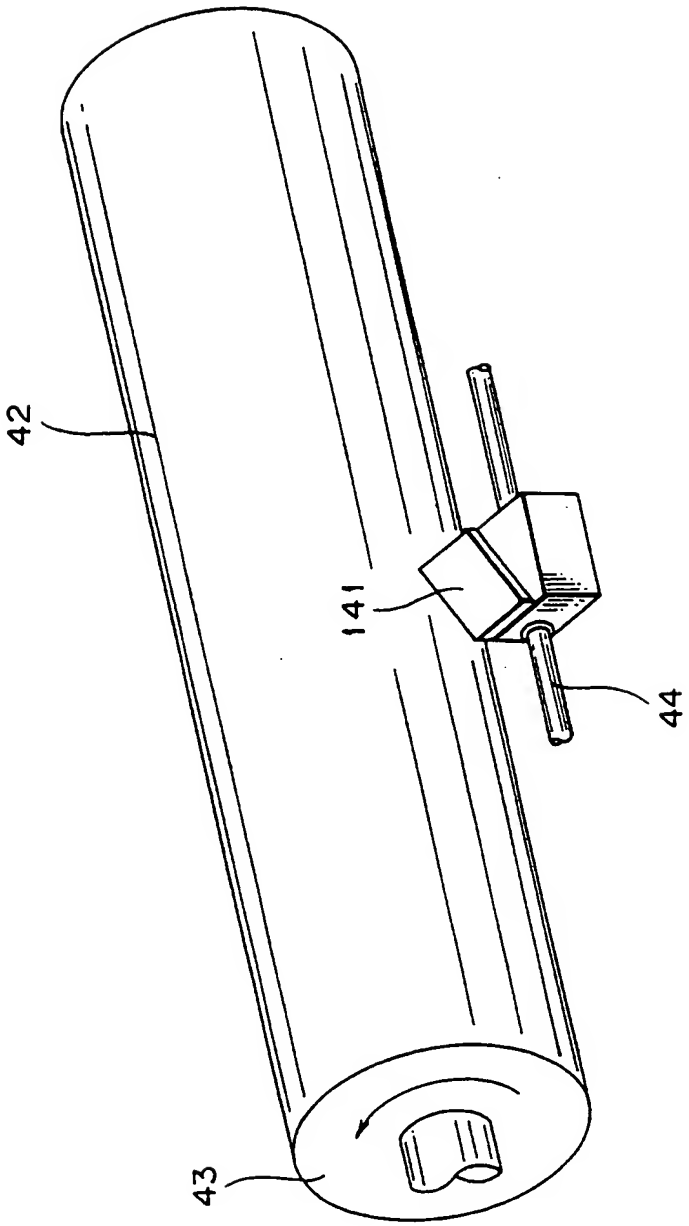
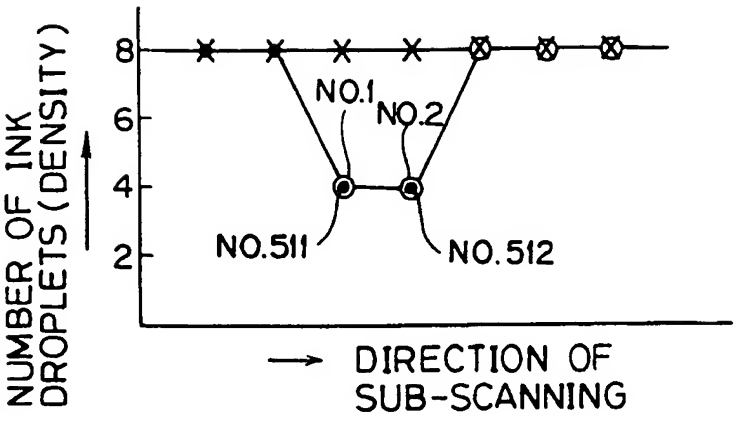


FIG.16



NUMBER OF INK DROPLETS AT FIRST MAIN-SCANNING

NUMBER OF INK DROPLETS AT SECOND MAIN-SCANNING

DENSITY VALUE BY RECORDING AT FIRST AND SECOND MAIN-SCANNING

FIG.17

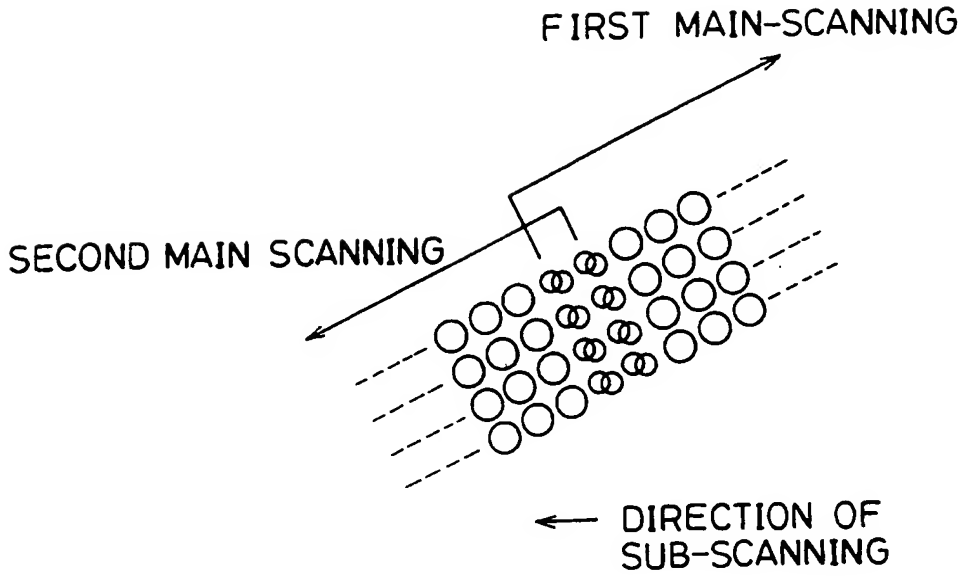

FIRST MAIN-SCANNING
SECOND MAIN SCANNING
DIRECTION OF
SUB-SCANNING

FIG.18